(19) Eur päisches Patentamt
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(11) EP 1 057 499 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.12.2000 Bulletin 2000/49

(51) Int Cl.[7]: **A61N 5/10**

(21) Application number: **00304559.8**

(22) Date of filing: **30.05.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **31.05.1999 CN 99108217**

(71) Applicant: **Shenzhen OUR International Technology & Science Co., Ltd.**
Shenzhen 518031 (CN)

(72) Inventors:
- **Song, Shipeng**
  Shenzhen 518031 (CN)
- **Liu, Guangwu**
  Shenzhen 518031 (CN)

(74) Representative: **Powell, Stephen David et al**
WILLIAMS, POWELL & ASSOCIATES
4 St Paul's Churchyard
London EC4M 8AY (GB)

(54) **Radiotherapy device**

(57) A whole-body radiotherapy device with radioactive sources (103) comprises a rotary fixing frame (801), a source body (101) and a collimator body (101) the rotating axis (6) being parallel to the longitudinal axis of a treatment couch (4). A plurality of radioactive sources and their beam channels are distributed in said source body, and the beams from said radioactive sources focus on the common focus point. Collimators (203) are located in the collimator body (201), and have the same distribution pattern as the radioactive sources. In the radial sectional planes, the radioactive sources (103) and their beam channels are located within a fan shaped area, the included angle of which is less than 90°. In an axial sectional plane, the corresponding angle is preferably less than 60°.

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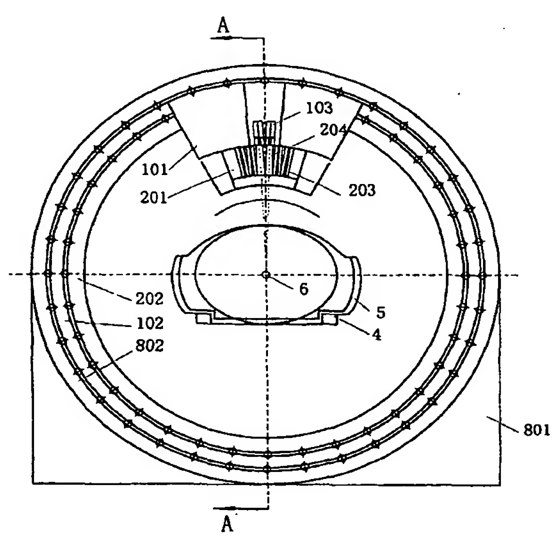

Fig. 1

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Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to radiotherapy devices, and more particularly to a rotary whole-body radiotherapy device with multiple radioactive sources.

[0002] A rotary whole-body radiotherapy device with multiple radioactive sources works on the principle of focusing while rotating. The multiple radioactive sources installed in the rotary source body are made to rotate in a family of coaxial conical planes, and directed at the common focus point coincident with the common vertex of the conical planes. As a result, the lesion tissue located at the common focus point is killed, while the healthy tissue is spared by receiving only momentary and harmless radiation. According to nuclear physics, the dose of the radioactive source at the focus point is in reverse proportion to the square of the distance between the radioactive source and the focus point. On the one hand, the distance from the centre of the radioactive source to the focus point should be as short as possible, and on the other hand, to implement rotary radiation of a disease site located at any part of the patient, there should be enough space from the exit of the collimator to the body surface of the patient.

[0003] In the prior art, the radioactive sources are uniformly distributed on the rotary cylindrical source body which rotates in a full angle range of 360°. Such an arrangement is known from CN patent no. 96213589.5, which discloses a rotary whole-body radiotherapy device with a source body of hollow cylindrical shape. Taking the plane which passes through the focus point and perpendicular to the centre line of the hollow cylinder as the datum plane, the radioactive sources are arranged in several groups on the cylindrical plane from latitudes 3° to 48° relative to the reference plane. On the surface plane of the cylindrical source body, the groups of channels are distributed uniformly along the circumference as viewed from the axial direction; they can be either spaced equidistantly in parallel, or ascending one line by each group. The collimators and the shielding rods are distributed in the same pattern as the radioactive sources, and as a result, beam channels are formed. Since the radioactive sources and the collimators are distributed within a full angle range of 360° along the circumference, the internal radius of the hollow cylinder should be no less than the distance from the exit of the collimators to the focus point. In order to direct radiation to the disease site at any part of the patient, said internal radius should be greater than the width of a human body, i.e. the distance from the exit of the collimators to the focus point should be greater than 48 centimetres. Therefore, in the prior art device, the radioactive sources have high total radiation activity, expensive production cost, low utility efficiency, and require critical shielding. As a result, the device is bulky in volume, heavy in weight, and high in production cost.

[0004] The present invention seeks to provide a whole-body radiotherapy device with multiple radioactive sources with a configuration such as to shorten the distance (referred to as source-focus-distance) from the radioactive sources to the focus point, and consequently improve the utility efficiency of the radioactive sources, and reduce the volume and weight of the device.

[0005] In accordance with the present invention, there is provided a whole-body radiotherapy device with multiple radioactive sources, comprising:

a frame with a source body and a collimator body and the rotating axis of which is arranged to be parallel to the longitudinal axis of a treatment region;
said source body having multiple radioactive sources and their beam channels located therein, and the beam from said radioactive sources focus on a common focus point through said beam channels;
said collimator body having collimators located therein, and said collimators have a similar distribution pattern to the radioactive sources;
said source body and collimator body being mounted on said rotary frame and being rotatable around the rotating axis;

characterised in that, in the radial sectional planes, said radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 90°.

[0006] Taking the plane which passes through the common focus point and perpendicular to the rotating axis as a datum plane, said datum plane is made to rotate around the line which passes through the common focus point and perpendicular to the rotating axis. As a result, a family of planes are formed which are defined as radial sectional planes. It is in these radial sectional planes that the radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 90°.

[0007] Since the radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 90°, instead of being distributed in a full angle range of 360° in said radial section planes, the radioactive sources and their beam channels can be limited to the region of a very narrow fan shape. Making the rotary radius of the collimator body longer than half width of the human body, the rotary radiotherapy at any place of the human body can be implemented by positioning the disease site at the focus point, and selecting the incidence angle and rotary range of the beam accordingly, instead of rotating in full angle range of 360°. Therefore, the contradictory demands of a large treatment space and a short source-focus-distance are successfully solved. With the guarantee of retaining enough treatment space for the whole body, the source-focus-distance is greatly reduced. As a result, the total radiation activity and the production cost of the sources are greatly reduced, the utility efficiency of the radioactive sources is improved, the volume size, the weight and the production cost of the de-

vice are reduced. Consequently, significant economic effect and social effect are achieved.

[0008] *Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, of which:*

Figure 1 is a radial (B-B) sectional diagram showing one preferred embodiment of a whole-body radiotherapy device with multiple radioactive sources in accordance with the present invention;

Figure 2 is an axial (A-A) sectional diagram of the whole-body radiotherapy device of Figure 1;

Figure 3 is an axial (A-A) sectional diagram showing another preferred embodiment of the present invention;

Figure 4 is a diagram showing the distribution of the radioactive sources in the source body of a whole-body radiotherapy device in accordance with the present invention;

Figure 5 is a diagram showing the distribution of the collimators and the shielding rods in the collimator body of a whole-body radiotherapy device in accordance with the present invention; and

Figure 6(a)-(f) are diagrams showing examples of radiation with different incident angles and rotary range according to different positions of the disease site.

[0009] Referring to Figure 1, in one preferred embodiment of the present invention, the whole-body radiotherapy device with multiple radioactive sources comprises source body 101, rotary source body fixing ring 102 which is fixed to said source body 101, collimator body 201, rotary collimator body fixing ring 202 which is fixed to said collimator body 201, support frame 801, and rotary support ring 802 which is fixed to said support frame 801. Multiple rolling bearings are installed between said rotary source body fixing ring 102 and said rotary support ring 802. As a result, said rotary source body fixing ring 102 is axially fixed with but can rotate *relative to said rotary support ring 802. Similarly, multiple* rolling bearings are installed between the rotary collimator body fixing ring 202 and the rotary source body fixing ring 102. The source body fixing ring 102 and the collimator body fixing ring 202 are driven to rotate by two servo motors respectively, and the source body 101 carried by the source body fixing ring 102 and the collimator body 201 carried by the collimator body fixing ring 202 are consequently driven to rotate. Thus, the relative position between the source body 101 and the collimator body 201 can be adjusted, and the source body 101 can be made to stay at any position, so that the initial and final incident angles of the source body 101 with relation to the common focus point 6 can be adjusted. As seen from the example shown in Figure 6(a), the initial incident angle is <DOF, the final incident angle is <DOE, and the rotating angle range is C.

[0010] In the source body 101, multiple radioactive sources 103 and their beam channels are distributed. Beam from said radioactive sources 103 pass through said beam channels and focus on the common focus point 6 located on the rotating axis 7. In the radial sectional planes, radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 90°. Said included angle is further preferred to be less than 30°. In this embodiment, the two lines of radioactive sources are spaced by 4.5°.

[0011] In the axial sectional plane, radioactive sources *and their beam channels are* located within a fan shaped area, the included angle of which is less than 60°. Referring to Figure 2, in this embodiment of the present invention, in the axial sectional plane, the radioactive sources and their beam channels are distributed in a fan shaped pattern with equal source-focus-distance. They are distributed within two regions whose included angles are from -25° to -5° and from 5° to 25° respectively. The radiation strength of each radioactive source 103 at the common focus point 6 is equal. With this distribution pattern, the shape of the radiation field at the focus point can be more approximately to a circle shape, and in the same time, the penumbra of the radiation field at the focus point in the *radial plane can be* reduced. The rotating axis 7 passes through the common focus point 6 and parallel to the longitudinal axis of the treatment couch. In order to keep balance while rotating, a source body counterweight 104 is installed in the rotary source body fixing ring 102, and a collimator body counterweight 206 is installed in the rotary collimator body fixing ring 202.

[0012] Referring to Figure 3, in another preferred embodiment of the present invention, in the axial sectional plane, the radioactive sources and their beam channels are distributed in a triangular pattern with non-equal source-focus-distance. With this distribution pattern, the radiation strength of radioactive sources 103 may not be equal with each other at the common focus point 6.

[0013] Referring to Figure 4, the radioactive sources 103 are distributed in two adjacent axial sectional *planes, and with a staggered distribution in different ra*dial sectional planes so that the beams of the radioactive source form non overlapped conical planes with others while rotating.

[0014] Referring to Figure 5, two sets 203, 205 of collimators with different diameter and one set of shielding rods are installed in the collimator body 201. Each set has the same distribution pattern as radioactive sources 103. By adjusting the longitude position (± 9°) of the collimator body 201 relative to the source body 101, the radioactive sources 103 located in the source body 101 can be registered with one set of collimators or the shielding rods. Then the source body 101 and the colli-

mator body 201 are made to rotate synchronously. As a result, one can select collimators of different diameters or shut off the beam automatically as desired within the rotating angle range, so as to shield sensitive organs of the patient.

[0015] As seen from Figures 6(a) to 6(f), the lesion is located at the left, the right, the upper left, the upper right, the lower left and the lower right of the patient respectively. In the plane which passes through the focus point 6 and is perpendicular to the rotating axis 7, the distance from the internal edge of the collimator body fixing ring 202 to the common focus point 6 is less then the full width but more than the half-width of the human body, e.g., 28 cm. The rotating angle range C of the source body and the collimator body is not just 360°, but is calculated based on the particular position of the lesion to avoid interference with the human body and treatment couch. Alternatively, the rotating angle range C can be decided by the doctor according to the incident depth of the beam. In treatment, by moving the treatment couch 4, the disease site is positioned at the focus point 6. Then the radiation is implemented within the rotating angle range selected according to the treatment plan. If one set of collimators is registered with the radioactive sources, the beam from the radioactive sources will reach the common focus point through the collimators. If a set of shielding rods is made to register with the radioactive sources, the beam will be blocked. The changing between the collimators and the shielding rod is realised by two servo motors which respectively drive the rotary source body fixing ring carried with the source body and the rotary collimator body fixing ring carried with the source body and the rotary collimator body fixing ring carried with the collimators, and then the source body and the collimator body are made to rotate synchronously. As a result, one can open or shut off the beam automatically as desired within the rotating angle range, so as to protect sensitive tissues of the patient.

Claims

1. A whole-body radiotherapy device with multiple radioactive sources, comprising:

   a frame with a source body and a collimator body and the rotating axis of which is arranged to be parallel to the longitudinal axis of a treatment region;
   said source body having multiple radioactive sources and their beam channels located therein, and the beam from said radioactive sources focus on a common focus point through said beam channels;
   said collimator body having collimators located therein, and said collimators have a similar distribution pattern to the radioactive sources;
   said source body and collimator body being mounted on said rotary frame and being rotatable around the rotating axis;

   characterised in that, in the radial sectional planes, said radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 90°.

2. The device as defined in claim 1, wherein, in the radial sectional planes, said radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 30°.

3. The device as defined in claim 1 or 2, wherein, in the axial sectional planes, said radioactive sources and their beam channels are located within a fan shaped area, the included angle of which is less than 60°.

4. The device as defined in any preceding claim, wherein, in the axial sectional planes, the radioactive sources and their beam channels are distributed in fan shaped pattern with equal source-focus-distance.

5. The device as defined in any of claim 1 to 3, wherein, in the axial sectional planes, the radioactive sources and their beam channels are distributed in a triangular pattern with non-equal source-focus-distance.

6. The device as defined in claim 1 or 2, wherein, said radioactive sources are distributed in two adjacent axial sectional planes which are spaced by 4° - 5°, and with a staggered distribution in different radial sectional planes.

7. The device as defined in claim 1 or 2, wherein, the initial and final incident angles of the source body with relative to the common focus point can be adjusted.

8. The device as defined in any preceding claim, and further comprising:

   a rotary support ring which is fixed with said fixing frame, and
   a rotary source body fixing ring which is fixed with said source body,
   wherein said rotary source body fixing ring is axially fixed with but can rotate relative to said rotary support ring.

9. The device as defined in claim 8, and further comprising:

   a rotary collimator body fixing ring which is fixed

with said collimator body,
wherein said rotary collimator body fixing ring is axially fixed with but can rotate relative to said rotary source body fixing ring.

10. The device as defined in any preceding claim, wherein said collimators are divided into several sets, each set of collimators have the same diameter, and have the same distribution pattern as said radioactive sources.

11. The device as defined in any preceding claim, wherein said collimator body has a set of shielding rods located therein, said shielding rods having the same distribution pattern as said radioactive sources.

12. The device as defined in any preceding claim, wherein, the internal radius of said collimator body is less than full width of the human body, but more than half-width of the human body.

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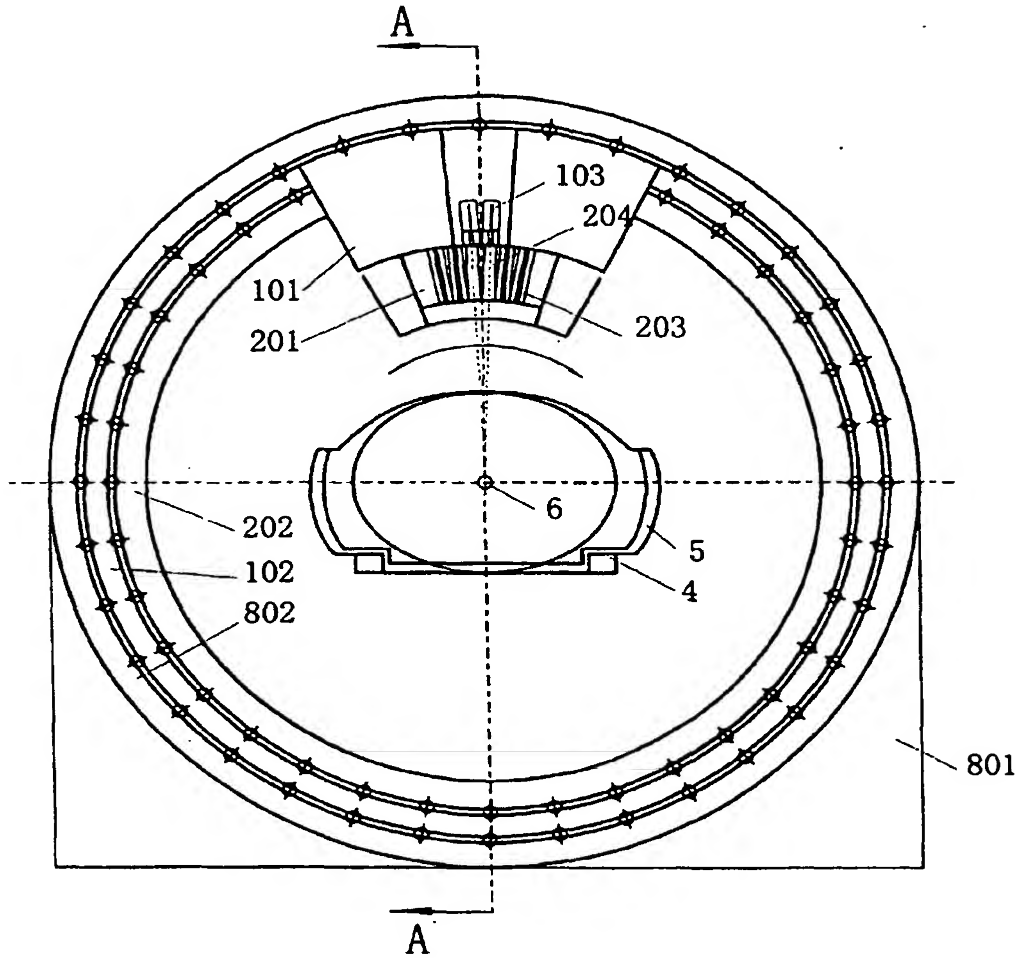


Fig. 1

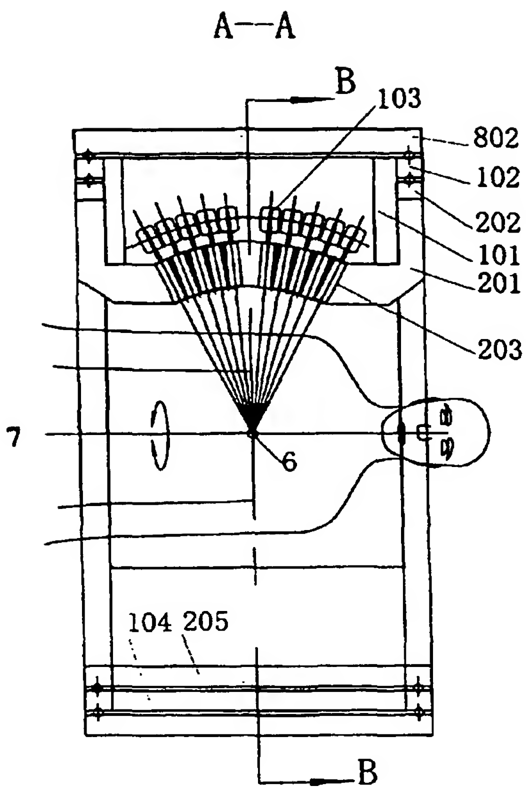
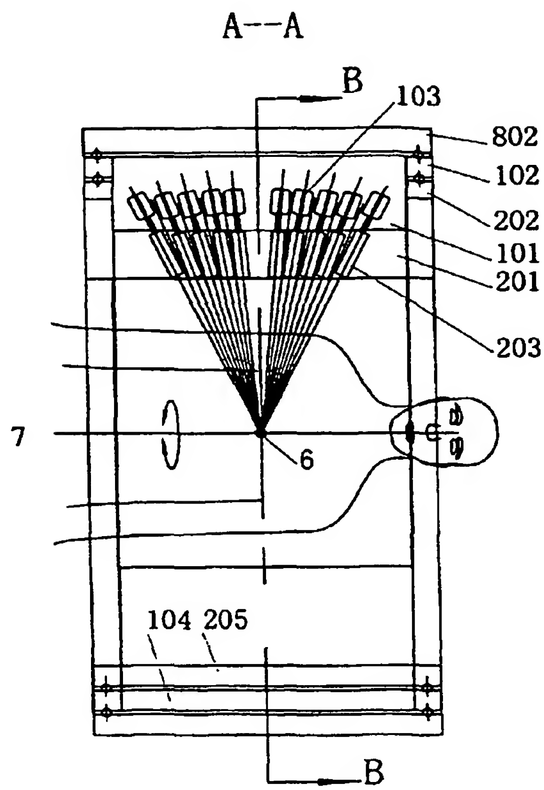

A--A
B
103
802
102
202
101
201
203
7
6
104 205
B

Fig. 2


A--A
B
103
802
102
202
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201
203
7
6
104 205
B

Fig. 3

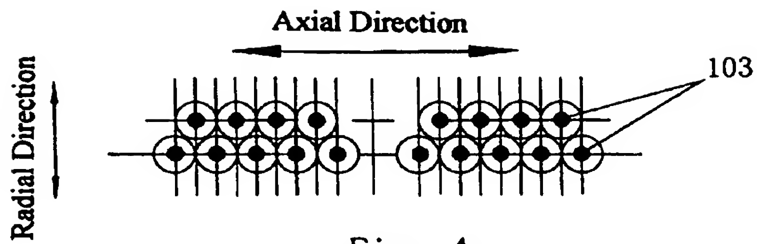
Axial Direction
Radial Direction
103

Fig. 4

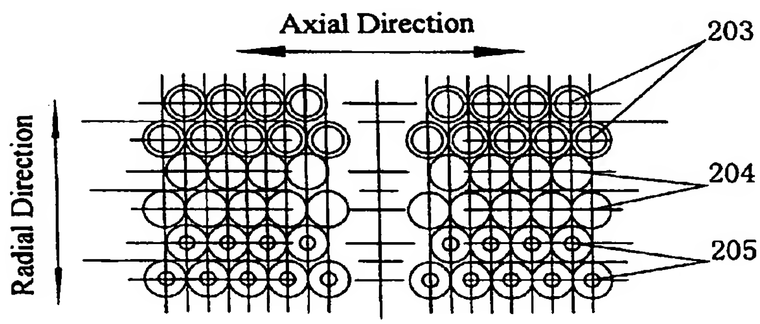
Axial Direction
Radial Direction
203
204
205

Fig. 5

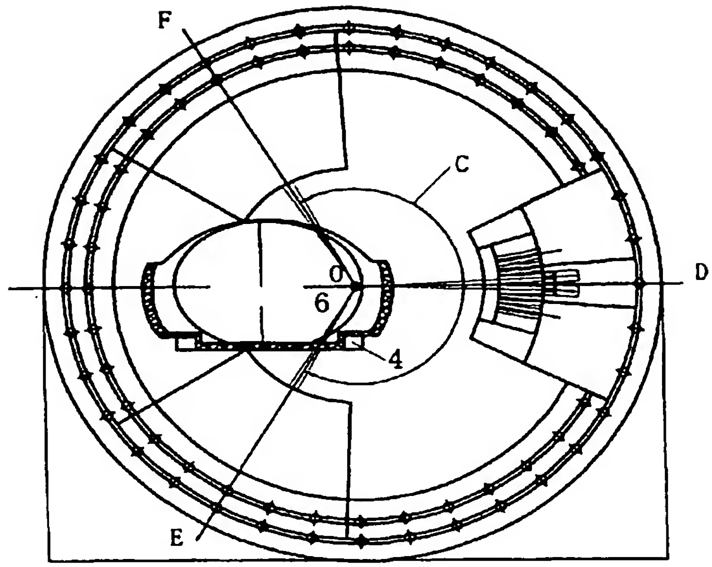

Fig 6 (A)

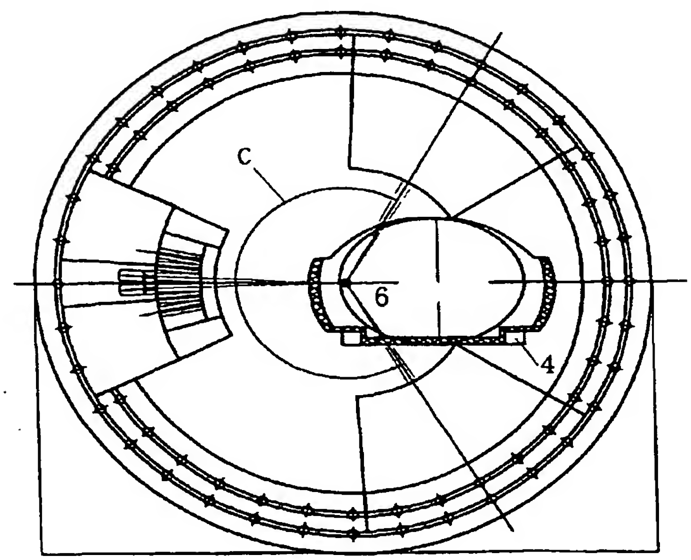

Fig 6 (B)

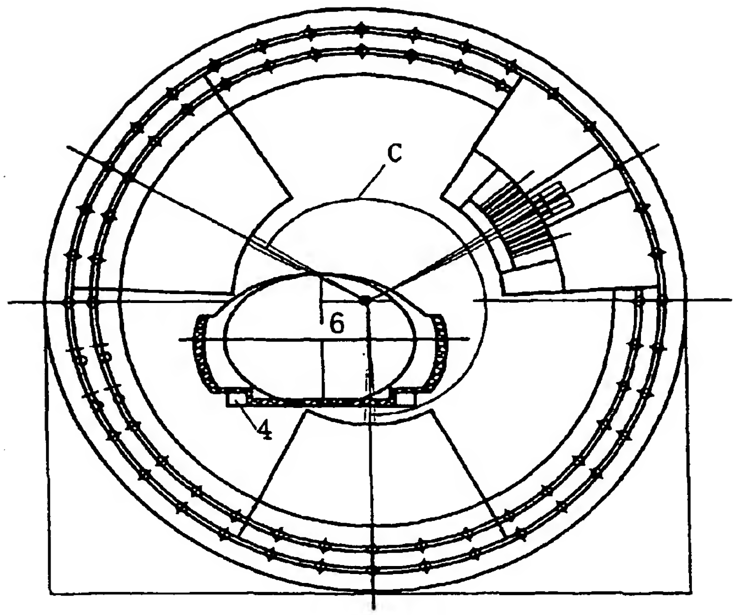

Fig 6 (C)

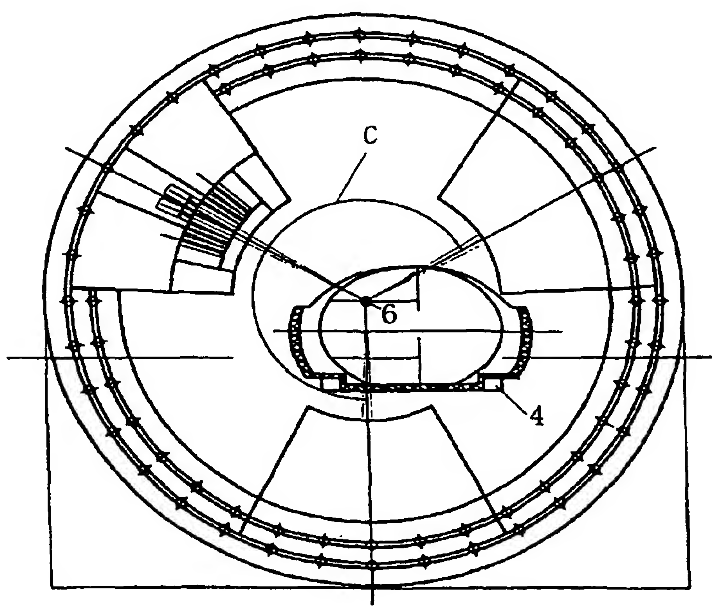

Fig 6 (D)

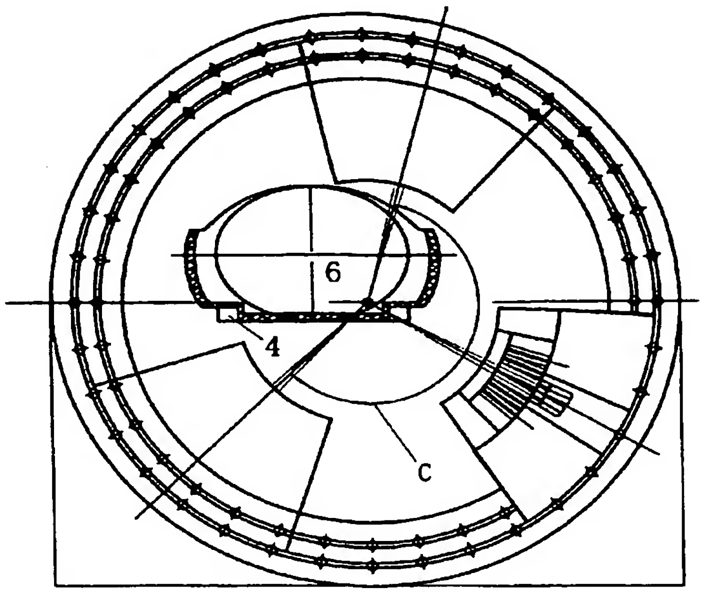

Fig 6 (E)

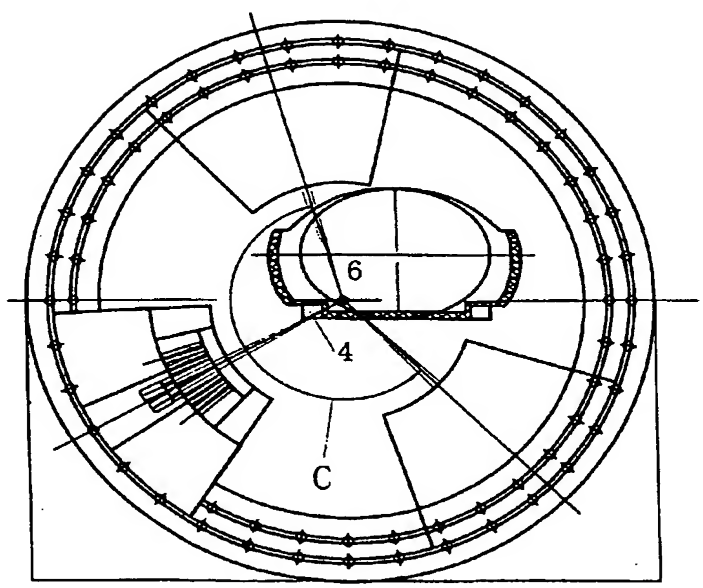

Fig 6 (F)